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Directional Drilling With Casing

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ABSTRACT

Casing while drilling (CwD) has proven to be an effective method of reducing drilling costs and solving drilling problems. Most of the current CwD activity focuses on drilling vertical wells, but interest in directional wells is increasing as CwD benefits in straight holes are demonstrated.

A directional CwD system has been run sufficiently to prove that directional drilling with casing is practical with casing sizes from 7 to 13 in. The system uses a wireline-retrievable- directional-drilling assembly to replace the conventional directional tools used when drilling with drill pipe. These tools have been used to drill to inclinations greater than 90° and have been retrieved and rerun at inclinations ranging from vertical to horizontal.

Directional CwD can be used for a broad range of directional applications to capture proven advantages demonstrated in vertical wells.

INTRODUCTION

Growing commercial activity shows that drilling with casing is increasingly accepted as a practical method of reducing drilling costs and solving drilling problems. This activity includes both onshore applications, in which the entire well is drilled with casing, and off-shore applications in the Gulf of Mexico and Gulf of Thailand, in which only the first hole section or two are drilled with casing.

Most CwD activity has been focused on drilling vertical intervals, but interest in drilling with casing in directional wells is increasing as the processes for drilling straight holes become proven, CwD benefits are demonstrated, and more versatile tools become available.

Vertical wells may be drilled with casing, using a simple system consisting primarily of a special bit attached to the casing that can be drilled out to run subsequent casing strings. But when there is a need to drill with a motor without rotating the casing, or the section cannot confidently be drilled with a single bit, then a retrievable drilling assembly that can be recovered and rerun is required. Even some sections that can be drilled with a drillout bit may be more cost-effectively drilled with a retrievable system.

Retrievable CwD equipment is required for directional wells because of the need to recover the expensive directional drilling and guidance tools, the need to have the capability to replace failed equipment before reaching the casing point, and the need for quick and cost-effective access to the formations below the casing shoe.

CWD PROCESS

The directional CwD system is composed of downhole and surface components that enable the use of normal oilfield casing, such as the drillstring, so that the well is simultaneously drilled and cased. A wireline-retrievable drilling assembly is suspended in a profile nipple located near the bottom of the casing. The drilling fluid is circulated down the casing’s inner diameter (ID) and up the annulus between the casing and wellbore. The casing is rotated from the surface with a top drive for all operations—except slide drilling—with a motor and bent housing assembly for oriented directional work.

The CwD BHA normally consists of a pilot bit with an under- reamer located above it that opens the hole to the final wellbore diameter. The pilot bit is sized to pass through the casing, and the under-reamer opens the hole to the size that is normally drilled to run casing.

Other downhole tools, in addition to the bit and under-reamer, are used as appropriate. For vertical drilling, stabilization is normally included on the assembly, and a steerable motor, measurement while drilling (MWD), and nonmagnetic collar are included in the BHA for directional drilling.

The drilling assembly is attached to the bottom of the casing with a special tool and referred to as the drill-lock assembly (DLA).

The casing string is attached to the top drive by a casing quick-connect without screwing into the top-casing coupling. The quick-connect, includes a slip assembly and an internal spear assembly. The use of the quick-connect speeds up the casing-handling operation and prevents damage to the threads by eliminating one make/break cycle.

Connections are made in a way similar to drillpipe connections—either in the mouse hole or over the rotary table, depending on the particular equipment that is available.

RETRIEVABLE DOWHOLE TOOLS

The tools used for most of the CwD field applications reported in the literature were limited to near-vertical wells because of the design of the DLA and running and retrieving tools.1,4 As experience was gained with the original tools and the requirements for directional work became better understood, a new generation of tools was developed.

These tools preserved the proven capability to axially and torsionally lock and unlock the drilling BHA to the casing, seal in the casing to direct the drilling fluid through the bit, locate the DLA in the profile without relying on precise wireline measurements, and bypass fluid around the tools for running and retrieving. New features added to the tools allow them to be run and retrieved in deviated wells with inclinations higher than 90°. The BHA can be released with a pump-down dart before running the wireline. Most of the tool complexity is placed in the running and retrieving tools, rather than in the BHA components that are subjected to drilling forces and vibration.

The directional-drilling BHA used with the CwD system normally consists of a pilot bit, under-reamer, steerable mud motor, MWD, and nonmagnetic drill collar(s). This is similar to the assembly that is commonly used for conventional directional drilling, except that the mud motor is often smaller than what would be used for conventional directional work in the same size hole.

The smaller motor required for some sizes of casing limits motor power, but this is of little consequence for casing sizes larger than 7 in. Similarly, the smaller motor is more flexible than would normally be used, and this, coupled with the inability to place full-gauge rigidblade stabilizers above the motor, can make the directional response a little more difficult to predict and control.

The final difference between a CwD and conventional directional assembly is that the bend in the motor is limited by the fact that the assembly must pass through a smaller casing size. The clearance between the motor and casing is less than would exist around the open hole and motor for conventional directional work. In general, though, an adequate bend angle can be run to drill the maximum curvature that is safe to use when drilling with casing.

WELL SELECTION CRITERIA

It is possible to drill directionally under some quite extreme conditions with a CwD system, but some candidate wells are much better for this process than others. Potential applications should be screened to ensure that they have a good probability of resulting in both technical and economic success.

Technical Criteria. Directional drilling with casing is in its infancy; much more progress can be expected in the future as a broad range of tools becomes available to use with it. But at the present time, directional drilling with casing smaller than 7 in. is somewhat limited. The small size of the motors that can be used with 5 1⁄2-in. casing leaves the bits underpowered and provides limited directional control. Directional drilling with the small motors can be accomplished, but it is most competitive in places in which it provides an enabling technology. It may be a viable option only when there are no alternatives for getting the casing into the well.

Directional drilling with 7-in. casing becomes much more practical with currently available motors and guidance systems. The motors used with larger casing sizes are sufficiently powerful and robust that they do not limit performance. The directional work is often conducted at shallower depths and at lower build rates with the larger casing sizes, which also make the guidance more effective.

In most cases, the outer diameter (OD) of the casing used for drilling is larger than the OD of the drillpipe and collars that would be used to drill the same size hole. This results in an increased stiffness, which increases the magnitude of the reversing stresses that occur when the pipe is rotated in any particular curvature. These reversing stresses cause fatigue and limit the build rate that is practical for any given size and grade of casing.

Stress associated with lateral vibration is also a common cause of fatigue when drilling with casing. Most reported CwD fatigue failures have occurred in vertical wells and are generally attributed to reversing stress from vibration. Fatigue failures are likely to be less common in directional wells than in vertical wells. The lower rotational speed used with steerable motors, combined with the damping of lateral vibration provided by the well's inclination, should result in fewer and lower-magnitude fatigue cycles.

Economic Criteria. There are a number of CwD benefits that result in cost savings. Most significant of these benefits are the reduced time required for tripping, reduced trouble time associated with lost circulation, and the ability to save the well when a problem does occur.

The primary advantage of directional drilling with casing is that it allows these types of advantages to be captured for directional wells. Directional drilling with casing does offer greater ease in orienting a steerable motor and a faster tripping time for changing BHA components, but the actual penetration rate probably suffers a slight penalty when drilling with smaller casings. For larger casing sizes and less severe directional profiles, the CwD benefits can be captured with no loss in directional efficiency or penetration rate.

In evaluating directional CwD candidate wells, it is best to first identify wells that have specific problems that may be solved by simultaneously drilling and casing the well. These may include things such as reducing lost circulation trouble time; driving the casing to a deeper depth in troublesome formations, such as depleted zones; drilling through unconsolidated formations; reducing trip time in high-cost operations; or using a smaller rig for in-field drilling off a platform.

CONCLUSION

CwD directional wells provide a practical alternative to drilling the wells conventionally and then running the casing as a separate process. It assures that the casing can be run to TD and captures many of the savings that have been proven for vertical CwD wells. For larger sizes of casing, no loss of efficiency occurs while drilling with the steerable tools below the casing. This allows the operator to take full advantage of trouble-avoidance benefits provided by CwD. Directional drilling with a smaller casing may sacrifice some drilling efficiency because of the requirement to use smaller motors, and is most advantageously applied in situations in which the CwD system is needed to provide an enabling technology, rather than an improvement in efficiency.